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(54) **ADJUSTING TENSION IN A TAPE MEDIA TO COUNTER TAPE DIMENSIONAL STABILITY (TDS) ERRORS IN A TAPE MEDIA**

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G11B 15/467	(2006.01)
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G11B 5/012	(2006.01)
G11B 20/18	(2006.01)

(52) **U.S. Cl.**

CPC ***G11B 15/43*** (2013.01); ***G11B 5/012*** (2013.01); ***G11B 5/52*** (2013.01); ***G11B 5/5504*** (2013.01); ***G11B 15/4678*** (2013.01); ***G11B 20/18*** (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

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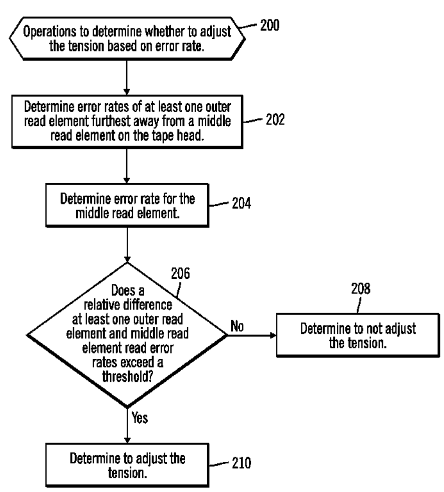
(57) **ABSTRACT**

Provided are a method, system, and program for adjusting tension in a tape media to counter tape dimensional stability (TDS) errors in a tape media. A determination is made of whether to adjust tension of the tape media based on a detected error rate of reading at least one of the tracks. The tension of the tape media is adjusted in response to determining to adjust the tension.

18 Claims, 8 Drawing Sheets



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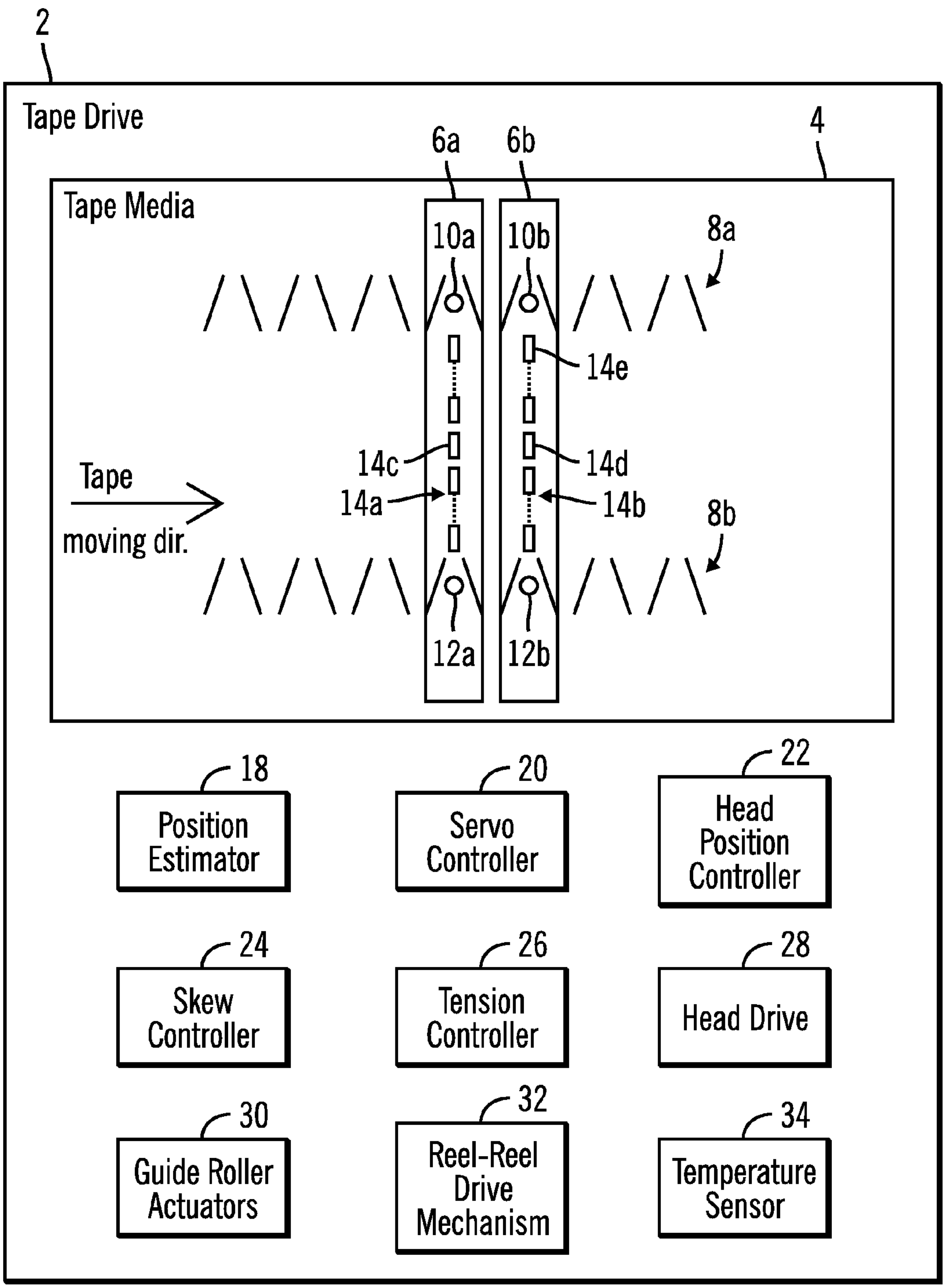

2
Tape Drive
4
Tape Media
6a
6b
10a
10b
8a
14e
14c
14d
14a
14b
Tape
moving dir.
8b
12a
12b
18
Position Estimator
20
Servo Controller
22
Head Position Controller
24
Skew Controller
26
Tension Controller
28
Head Drive
30
Guide Roller Actuators
32
Reel-Reel Drive Mechanism
34
Temperature Sensor

FIG. 1

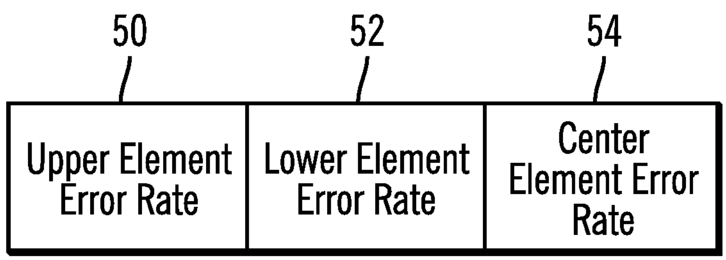

50
52
54
Upper Element Error Rate
Lower Element Error Rate
Center Element Error Rate

FIG. 2

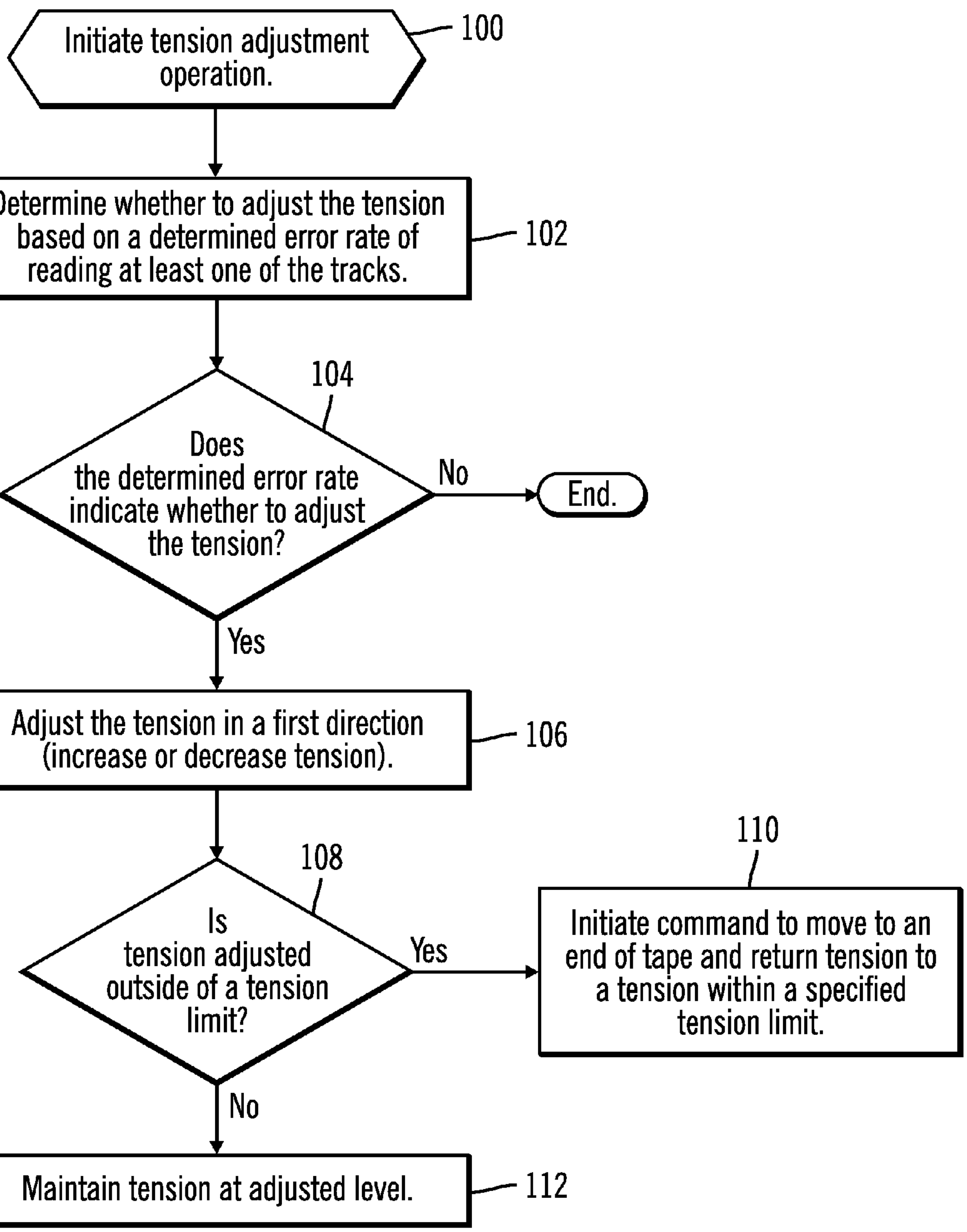

Initiate tension adjustment operation.
100
Determine whether to adjust the tension based on a determined error rate of reading at least one of the tracks.
102
104
Does the determined error rate indicate whether to adjust the tension?
No
End.
Yes
Adjust the tension in a first direction (increase or decrease tension).
106
108
Is tension adjusted outside of a tension limit?
Yes
110
Initiate command to move to an end of tape and return tension to a tension within a specified tension limit.
No
Maintain tension at adjusted level.
112

FIG. 3

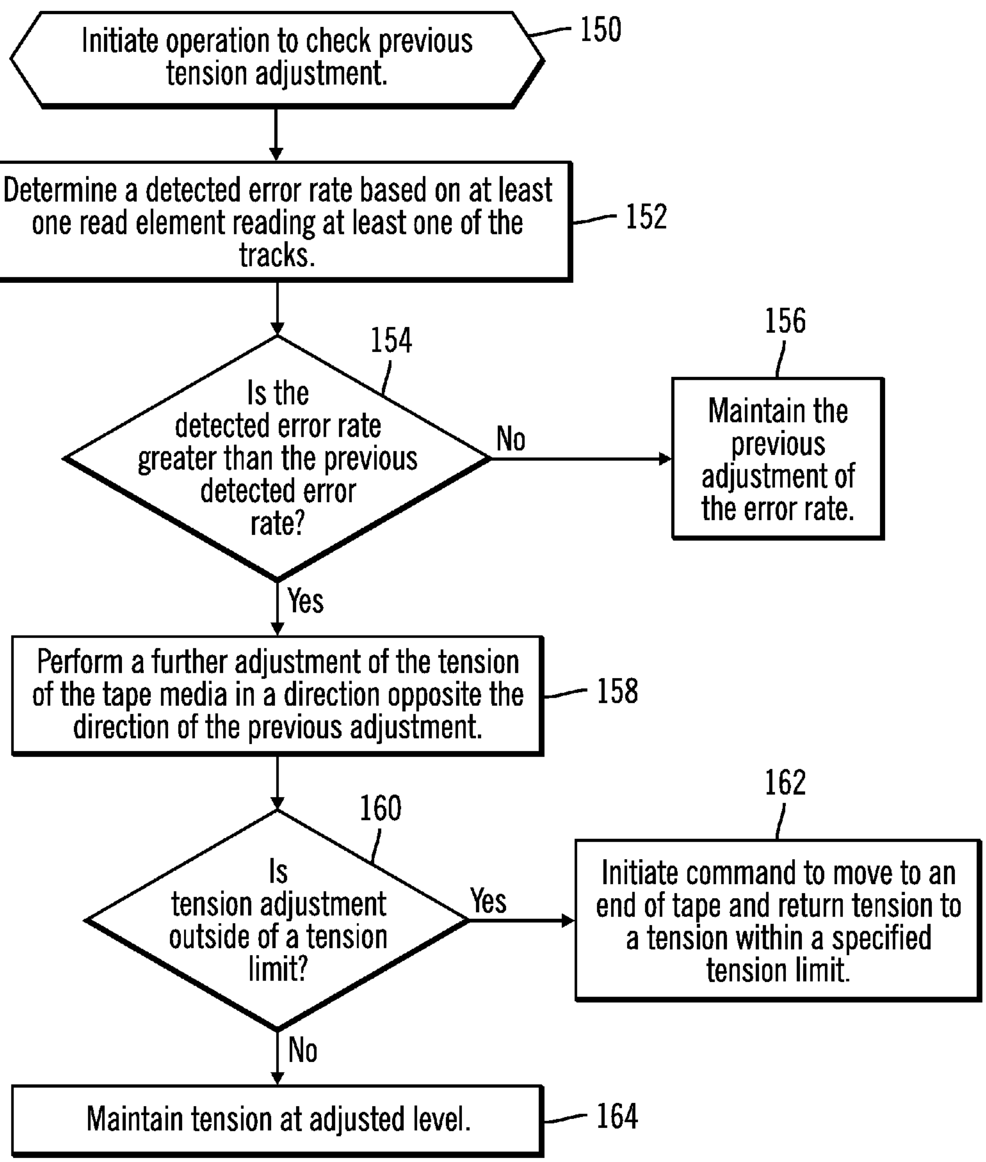

Initiate operation to check previous tension adjustment.
150
Determine a detected error rate based on at least one read element reading at least one of the tracks.
152
Is the detected error rate greater than the previous detected error rate?
154
No
Maintain the previous adjustment of the error rate.
156
Yes
Perform a further adjustment of the tension of the tape media in a direction opposite the direction of the previous adjustment.
158
Is tension adjustment outside of a tension limit?
160
Yes
Initiate command to move to an end of tape and return tension to a tension within a specified tension limit.
162
No
Maintain tension at adjusted level.
164

FIG. 4

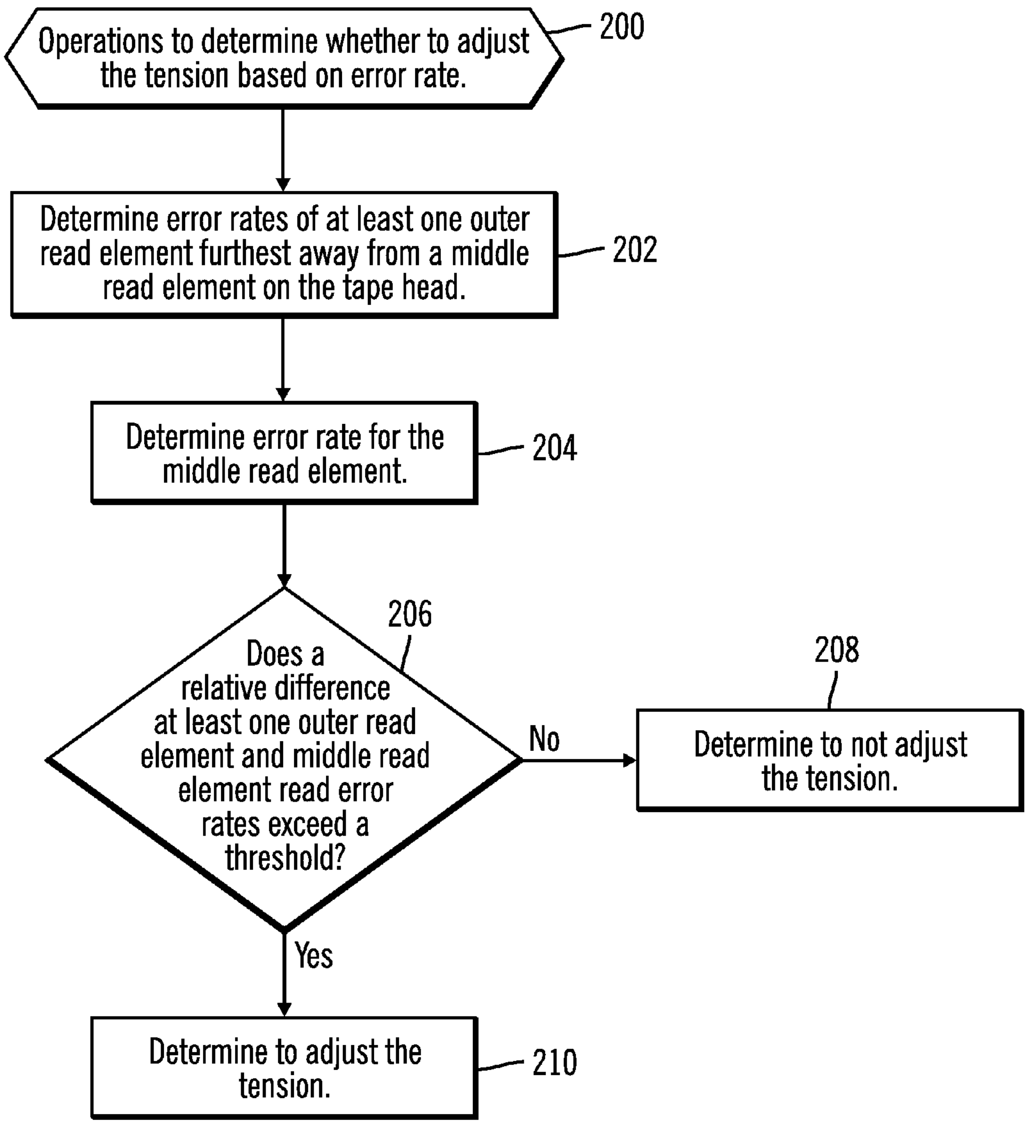

Operations to determine whether to adjust the tension based on error rate.
200
Determine error rates of at least one outer read element furthest away from a middle read element on the tape head.
202
Determine error rate for the middle read element.
204
Does a relative difference at least one outer read element and middle read element read error rates exceed a threshold?
206
No
Determine to not adjust the tension.
208
Yes
Determine to adjust the tension.
210

FIG. 5

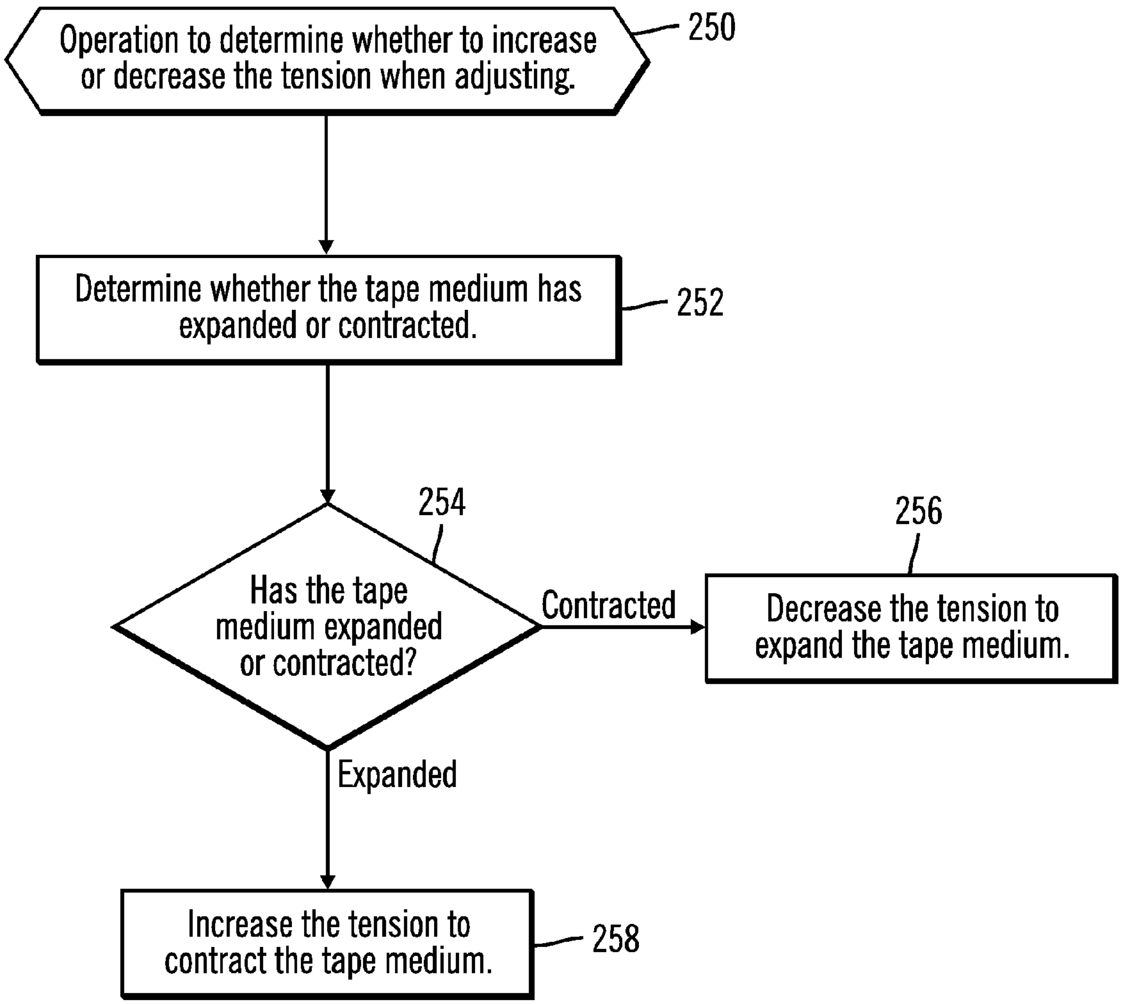
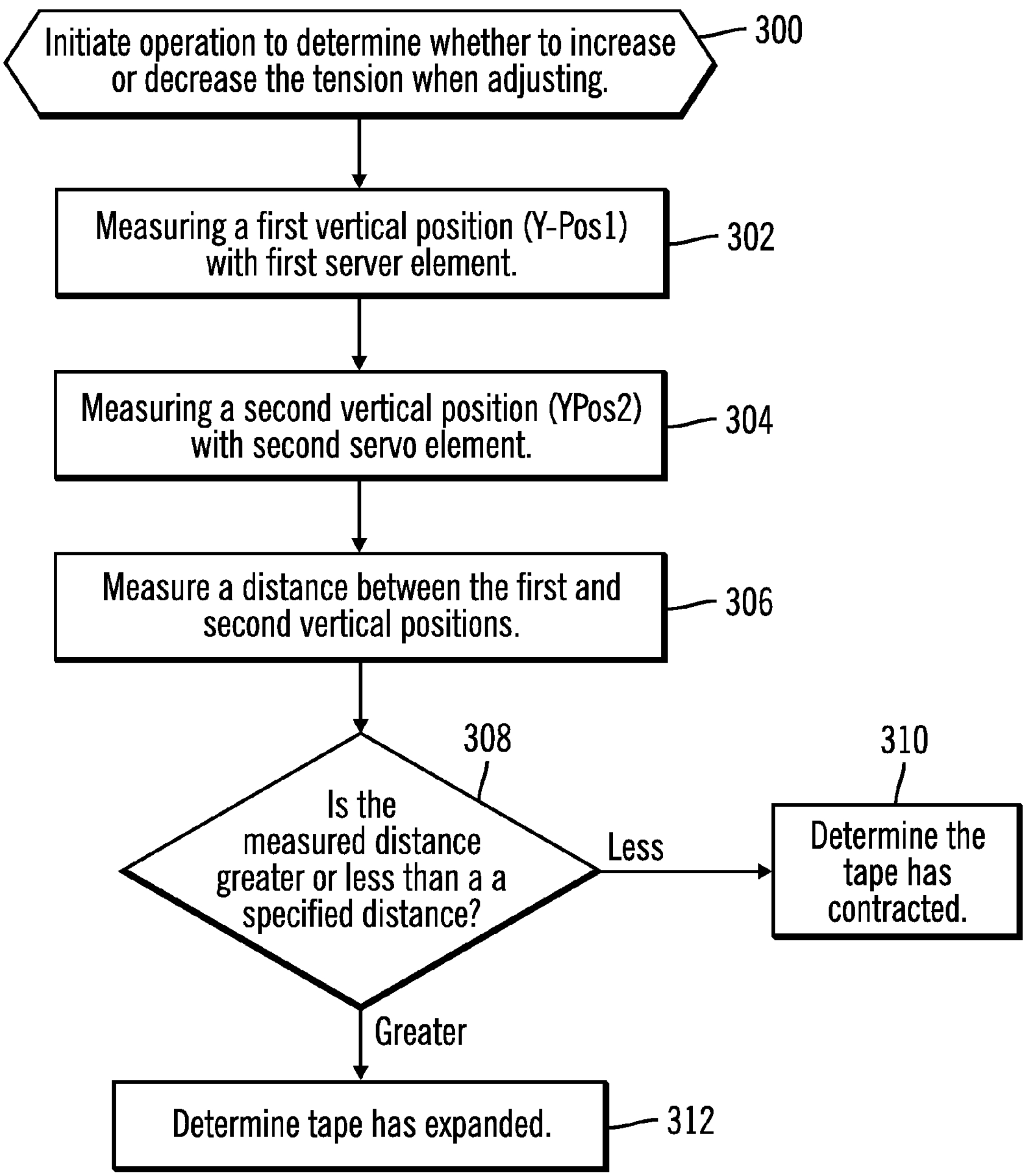

Operation to determine whether to increase or decrease the tension when adjusting.
250
Determine whether the tape medium has expanded or contracted.
252
254
Has the tape medium expanded or contracted?
Contracted
256
Decrease the tension to expand the tape medium.
Expanded
Increase the tension to contract the tape medium.
258

FIG. 6



Initiate operation to determine whether to increase or decrease the tension when adjusting.
300
Measuring a first vertical position (Y-Pos1) with first server element.
302
Measuring a second vertical position (YPos2) with second servo element.
304
Measure a distance between the first and second vertical positions.
306
308
Is the measured distance greater or less than a a specified distance?
Less
310
Determine the tape has contracted.
Greater
Determine tape has expanded.
312

FIG. 7

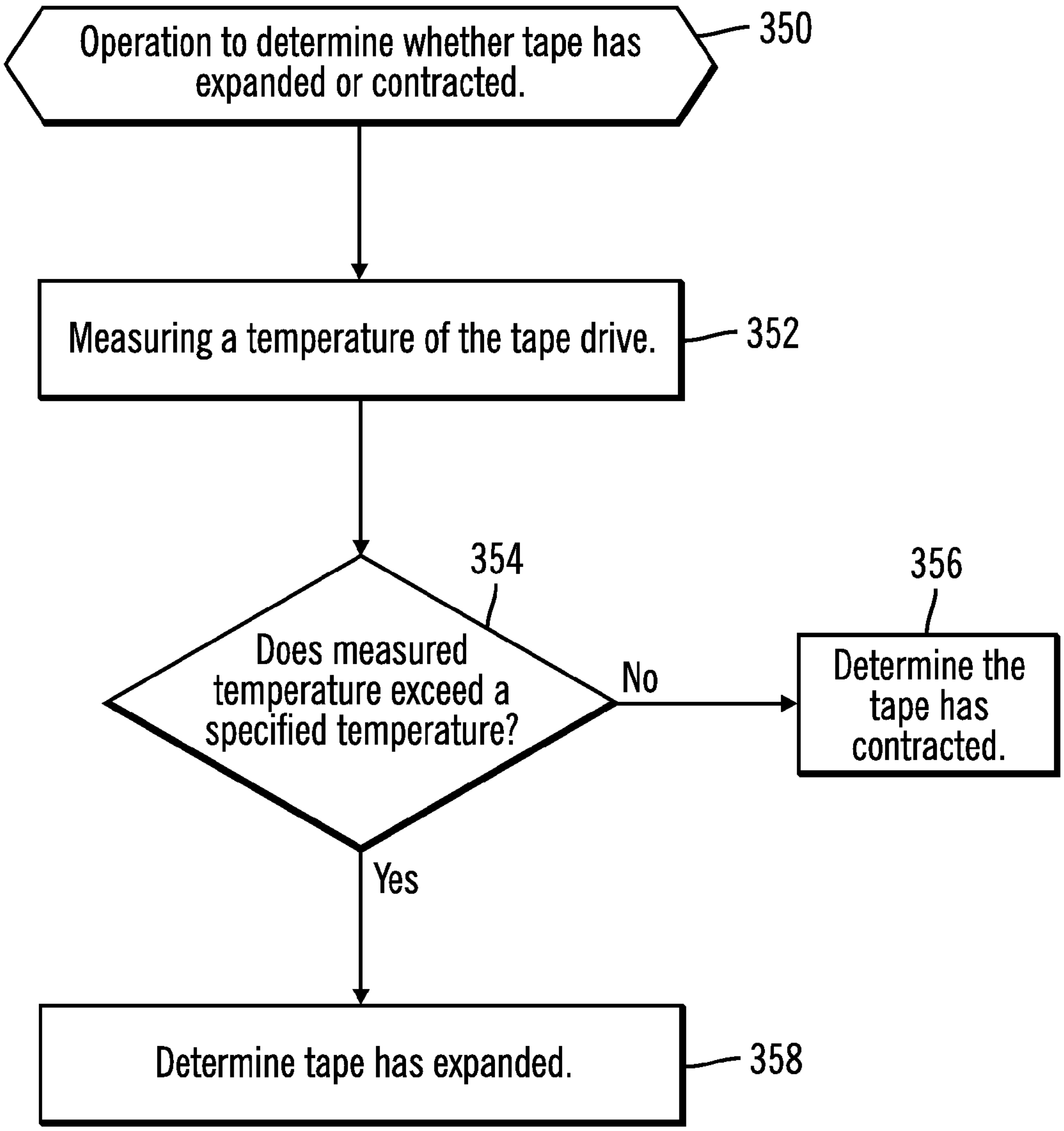

Operation to determine whether tape has expanded or contracted.
350
Measuring a temperature of the tape drive.
352
Does measured temperature exceed a specified temperature?
354
No
Determine the tape has contracted.
356
Yes
Determine tape has expanded.
358

FIG. 8

ADJUSTING TENSION IN A TAPE MEDIA TO COUNTER TAPE DIMENSIONAL STABILITY (TDS) ERRORS IN A TAPE MEDIA

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation of U.S. patent application Ser. No. 13/887,136, filed May 3, 2013, which application is incorporated herein by reference in its entirety.

FIELD OF THE INVENTION

The present invention relates to a computer program product, system, and method for adjusting tension in a tape media to counter tape dimensional stability (TDS) errors in a tape media.

DESCRIPTION OF THE RELATED ART

In the design of a tape drive system, the expansion and contraction of the magnetic tape may have to be taken into account. Such expansions and contractions of the magnetic tape cause a change in the dimension of the magnetic tape. Dimensional changes of the magnetic tape may be caused by environmental factors, aging of the magnetic tape, and other factors. For example, a magnetic tape may change its dimensions when exposed to different temperatures and humidity factors. Changes in the dimension of the magnetic tape may impact the successful reading of data that has been previously written on the tape under a different environment condition.

Tape Dimensional Stability (TDS) is a measure of the positional stability of the magnetic data tracks relative to each other and is a function of the tape properties and environmental effects such as temperature, humidity, tension, creep, etc. These environmental factors can cause the tape to expand or contract laterally, across the width of the tape. Therefore, when a tape is written to in one environmental condition and subsequently read from in another environmental condition, the position of the data tracks across the tape width can change enough to cause signal degradation or read errors. Minimizing tape dimensional changes may ensure the robustness of the reading data in a different environmental condition.

In a tape drive, a TDS condition may be detected by measuring vertical positions in the two servo channels on opposite sides of the data channel and determining the difference to find the TDS. The tape may be determined to have expanded if the upper vertical position in the servo channel is read below the reference position and determined to have contracted if the upper vertical position is determined to be above the reference upper vertical position. The middle read element of a tape head having multiple read elements may be positioned between the read upper and lower vertical positions in the servo channel.

SUMMARY

Provided are a method, system, and program for adjusting tension in a tape media to counter tape dimensional stability (TDS) errors in a tape media. A determination is made of whether to adjust tension of the tape media based on a detected error rate of reading at least one of the tracks. The tension of the tape media is adjusted in response to determining to adjust the tension.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates an embodiment of a tape drive unit.

FIG. **2** illustrates error rate information gathered in the tape drive unit.

FIG. **3** illustrates an embodiment of operations to adjust the tension of the tape media in the tape drive unit.

FIG. **4** illustrates an embodiment of operations to determine further adjustment of the tension.

FIG. **5** illustrates an embodiment of operations to determine whether to adjust the tension based on an error rate.

FIG. **6** illustrates an embodiments of operations to determine whether to increase or decrease the tension when adjusting.

FIGS. **7** and **8** illustrate embodiments of operations to determine whether the tape media has contracted or expanded.

DETAILED DESCRIPTION

Described embodiments provide techniques for using read error rates on the read elements on a tape head to determine whether the tape has contracted or expanded which could indicate TDS errors. Described embodiments adjust the tension of the tape media based on the read error rates experienced in the read elements.

FIG. **1** illustrates an embodiment of a tape drive **2** unit to read a magnetic tape media **4** in a tape cartridge (not shown) inserted in the tape drive **2**. The tape drive **2** includes a modular unit of heads **6***a*, **6***b* to write and read data written to the tape media **4**. The tape media **4** includes servo bands **8***a* and **8***b* of servo patterns read by the heads **6***a*, **6***b* to determine the position of the heads **6***a*, **6***b* with respect to the tape media **4** to allow adjustment of the head position to write to the correct locations. Head **6***a* includes servo read elements **10***a* and **12***a* and a number of write and/or read elements **14***a* to read/write data on the tape media **4**. Head **6***b* includes servo read elements **10***b* and **12***b* and a number of write and/or read elements **14***b* to read/write data on the tape media **4**. The heads **6***a* and **6***b* may be manufactured within a Micro-electromechanical systems (MEMS) tape head. In certain embodiment, each head **6***a*, **6***b* may include 32 or some other number of read/write elements

In one embodiment, read/write elements **14***a* include at least one write element **14***c* and read/write elements **14***b* include at least one read element **14***d* at a corresponding position on head **6***b* as the position of the at least one write element **14***c* on head **6***a*. Read element **14***d* on head **6***b* may read data written by write element **14***c* on head **6***a*, where the write **14***c* and read elements **14***d* are at corresponding positions on the heads **6***a*, **6***b*, so that a read following write operation can be performed. In further embodiments, the elements **14***a* and **14***b* may each include alternating read and write elements at corresponding positions. In one embodiment, if elements **14***a* include a write element at a position, the elements **14***b* would include a read element at the corresponding position and if elements **14***b* include a read element at a position, the elements **14***b* would include a write element at the corresponding position.

The elements on the read head **14***b* may comprise read elements, such that element **14***d* is a middle read element and read elements **14***e* and **14***f* are outer read elements furthest away from the middle read element **14***c*.

The tape drive **2** includes a position estimator **18**, servo controller **20**, head position controller **22**, skew controller **24**, tension controller **26**, head drive **28**, guide roller actuators **30**, a reel-reel drive mechanism **32**, and a temperature sensor **34** to measure a temperature within the tape drive **2**. The position estimator **18** may process the servo read signals, read by the servo read elements servo read elements **10***a*, **10***b*, **12***a*, **12***b*, to produce position error signals (PES) provided to the head position controller **22** to move the heads **6***a*, **6***b* transversely, across the tape movement direction, to correct for position errors. As discussed, the heads **6***a*, **6***b* may be integrated in the same module so that the head drive **28** moves the integrated head module.

The servo controller **20** receives from the position estimator **18** the positions of the servo read elements **10***a*, **10***b*, **12***a*, **12***b* to calculate a skew error signal (SES), comprising an estimate of the skew angle of the tape media **4** relative to the heads **6***a*, **6***b*. The servo controller **20** supplies the SES to the skew controller **24** which supplies control signals to the guide roller actuators **30** to tilt guide rollers (not shown) in the tape media **4** path to counter tape skew. The servo controller **20** may further supply control signals to a tension controller **26**. The tension controller **26** controls reel-to-reel drive mechanism **32** to adjust a motor moving the tape media **4** to counter tension variation.

The write elements **14***a*, **14***b* may write to tracks in one direction then wrap around and write in the opposite direction, writing tracks to different bands on the tape media **4**. There may be multiple data bands and servo bands on the tape media **2** although only one data band and two servo bands **8***a*, **8***b* are shown.

As discussed, if there are TDS errors, the read heads **14***b* may read outside of the tracks due to the tape contracting or expanding so that the read heads can no longer maintain their position within the tracks on the tape due to expansion or contraction.

FIG. **2** illustrates an embodiment of information the servo controller **20** processes to determine whether to adjust the tension, including an upper element read error rate **50** comprising a read error rate measured at the upper read element **14***e*, a lower element read error rate **52** comprising a read error rate measured at the lower read element **14***f*, and a middle read element error rate **54** comprising a read error rate measured at the middle read element **14***d*. The read error rates **50**, **52**, **54** may be determined using error correction codes (ECC) to determine a rate at which errors are being read by the read elements **14***d*, **14***e*, **14***f*.

FIGS. **3**-**8** illustrate an embodiment of operations performed by the components of the tape drive unit **2** to determine whether to adjust the tension of the tape media **4** to compensate for TDS errors.

FIG. **3** illustrates an embodiment of operations performed by the components of the tape drive **2**, such as the position estimator **18**, servo controller **20**, and tension controller **26** to adjust the tension of the tape media for TDS errors. Upon initiating (at block **100**) a tension adjustment operation, which may be initiated periodically, the servo controller **20** and other components determine (at block **102**) whether to adjust the tension based on a determined read error rate of reading at least one of the tracks by one or more of the read elements **14***d*. In this way the read error rate of the outer read elements **14***e*, **14***f* and the middle read element **14***d* are used to indicate an extent of a TDS error. If the determined error rate indicates to adjust the tension, then the servo controller **20** sends a command to the tension controller **26** to adjust (at block **106**) the tension a first direction, i.e., increase or decrease the tension. The tension adjustment direction may be based on a preselected tension adjustment or be based on a determination of whether the tape media **4** expanded or contracted, such as described with respect to FIGS. **7** and **8**. If the determined read error rate does not indicate that the tension should be adjusted, i.e., indicate there is a TDS error, then control ends.

If (at block **108**) the tension adjustment is outside of a tension limit, such as specified in a specification for the tape media **4**, then the servo controller **20** initiates (at block **110**) a command to move to an end of the current wrap in the tape media **4** and instruct the tension controller **26** to return to a tension within a specified tension limit, such as an initial default tension. If (at block **108**) the tension adjustment is not outside the tension limit, then the tension is maintained (at block **112**) at the adjusted level.

FIG. **4** illustrates an embodiment of operations performed by the components of tape drive **2**, such as the position estimator **18**, servo controller **20**, and tension controller **26** to check a previous tension adjustment. Upon initiating (at block **100**) an operation to check a previous tension adjustment after adjusting the tension according to the operations of FIG. **3**, a determination is made (at block **152**) of a detected error rate resulting from one of the read elements **14***b* reading at least one of the tracks. If (at block **154**) the detected error rate is less than the previous detected error rate resulting in the previous tension adjustment, then the servo controller **20** maintains (at block **156**) the previous adjustment of the error rate, performed according to the operations of FIG. **3**. If (at block **154**) the detected error rate is greater than the previous detected error rate, meaning the error rate has worsened since the previous tension adjustment, then the servo controller **20** controls the tension controller **26** to perform (at block **158**) a further adjustment of the tension of the tape media **6** in a direction opposite the direction of the previous tension adjustment. The previous and further determined error rates, tension adjustments, and directions of the adjustments may further be referred to as first and second error rates, tension adjustments and directions, or other terms to reference previous and current operations for adjustment.

For instance, if the first, i.e., previous, tension adjustment according to FIG. **3** increased or decreased the tension, then the second, i.e., current or further, adjustment according to FIG. **4** would reverse the first adjustment, by adjusting tension in the opposite direction, decrease or increase. To reverse the first adjustment, the second adjustment may be by a greater than the first adjustment to not only reverse the effect of the first adjustment, increase or decrease tension, but to change the tension in the opposite direction to reverse the tension adjustment beyond what the tension controller **26** applied before the first adjustment. If (at block **160**) the second tension adjustment is outside of a tension limit, such as specified in a specification for the tape media **4**, then the servo controller **20** initiates (at block **162**) a command to move to an end of the current wrap in the tape media **64** and instruct the tension controller **26** to return to a tension within a specified tension limit, such as an initial default tension. If (at block **160**) the second tension adjustment is not outside the tension limit, then the tension is maintained (at block **164**) at the adjusted level.

In one described embodiment, the tension adjustment was to either increase or decrease the tension by a fixed value depending on whether the error rate increased since the previous tension adjustment. In a further embodiment, the second tension adjustment in the direction opposite the previous adjustment may be scaled based on an extent of the increase in the error rate, such that the amount of the second tension adjustment may vary depending on the magnitude of the increase in the error rate to provide greater resolution in controlling the subsequent tension adjustment. Further, the first or previous tension adjustment may also be scaled based on the magnitude of the first determined error rate to provide more fine tuned control of the tension adjustment.

FIG. **5** illustrates an embodiment of operations performed by the components of tape drive **2**, such as the position estimator **18**, servo controller **20**, and tension controller **26** to determine whether to adjust the tension using a read error rate, which may comprise the operation performed at block **102** in FIG. **3**. Upon initiating (at block **200**) the operation to adjust the tension based on the read error rate, the servo controller **20** determines (at block **202**) read error rates of at least one outer read element **14***e*, **14***f* furthest away from the middle read element **14***e* on the tape head **6***b*, and determines (at block **204**) the error rate for the middle read element **14***d*. The servo controller **20** determines (at block **206**) a relative difference of the read error rate experienced by at least one outer read element **14***e*, **14***f* and the middle read element **14***d*, to determine the extent to which the outer read error rates exceed the read error rate at the middle read element **14***d*. A higher error rate at the outer read elements **14***e*, **14***f* indicates that there has been expansion or contraction which affects the outer read channels more. If (at block **206**) the relative difference in error rates does not exceed a threshold, then the determination is to not adjust the tension. If (at block **206**) the relative difference does exceed the threshold, then the determination (at block **210**) is to adjust the tension. If both the outer read element **14***e*, **14***f* read error rates are considered, then the determination may require that one or both measured error rates exceed the threshold to determine to adjust tension. As discussed the tension adjustment may comprise a fixed adjustment value or a tension adjustment amount that is scaled by the magnitude of the determined error rates.

FIG. **6** illustrates an embodiment of operations performed by the components of tape drive **2**, such as the position estimator **18**, servo controller **20**, and tension controller **26**, to determine whether tension should be increased or decreased in block **106** in FIG. **3**. With respect to FIG. **6**, upon initiating the operation (at block **250**), the servo controller **20** determines whether the tape media **4** has expanded or contracted. If (at block **254**) the tape media **4** has contracted, the tension controller **26** is signaled to decrease (at block **256**) the tension to expand the tape medium **4**. If (at block **254**) the tape media **4** has expanded, then the tension is increased (at block **258**) to contract the tape medium **26**.

FIGS. **7** and **8** illustrate embodiments of operations performed by the components of the tape drive **2**, such as the position estimator **18**, servo controller **20**, and tension controller **26**, to determine whether the tape media **4** has expanded or contracted. This information may be used with respect to the operations in FIG. **6** when determining whether tension should be increased or decreased.

With respect to FIG. **7**, upon initiating (at block **300**) the operation to determine the direction in which to increase the tension, the position estimator **18** measures (at block **302**) a first vertical position (Y-Pos1) with a first servo element **10***b* and measures (at block **304**) a second vertical position (Y-Pos2) with a second servo element **12***b* determining whether to increase A distance between the two vertical positions (Y-Pos1 minus Y-Pos2) is measured (at block **306**). If (at block **308**) the measured distance is less than a specified or initial state distance for the servo positions, then the determination is that the tape has contracted (at block **310**). Otherwise, if the distance is greater than the specified or initial distance, then the determination is that the tape has expanded (at block **312**).

With respect to FIG. **8**, upon initiating the operation (at block **350**) to determine whether the tape has expanded or contracted, the servo controller **30** determines (at block **352**) a measurement of a temperature of the tape drive **2** from the temperature sensor **34**. If (at block **354**) the measured temperature does not exceed a specified temperature, then a determination is made that the tape media **4** has contracted (at block **356**), otherwise the tape media **4** is determined to have expanded (at block **358**).

In a further embodiment, the tension is adjusted based on a default adjustment, either increase or decrease, and then there is a second adjustment if the read error rate does not improve. In this further embodiment, the adjustment is set to a default or random value not related to any effort to determine that the tape media **4** has expanded or contracted.

Described embodiments provide techniques to compensate for TDS tracking errors that occur due to tape expansion or contraction. Described embodiments, use an error rate, such as the read error rate at the outer read elements and middle read element, to determine whether errors are resulting from TDS phenomena, and then adjust the tension to accommodate for a TDS error to reverse the perceived expansion or contraction that has occurred.

The described logic of the components of the tape drive **2**, including 18, 20, 22, 24, 26, 28, 30, 32, 34 may be implemented in hardware as discrete logic, such as an ASIC (application specific integrated circuit), FPGA (field programmable gate array), custom processors, etc.

The described logic of the components of the tape drive **2**, e.g., 18, 20, 22, 24, 26, 28, 30, 32, 34, shown in FIG. **1** may alternatively be implemented in subroutines in programs or other software implementations executed by a processor. Such programs implementing the operations of the servo channel components described with respect to FIG. **1** may be implemented in a computer readable medium, such as magnetic storage medium (e.g., hard disk drives, floppy disks, tape, etc.), optical storage (CD-ROMs, DVDs, optical disks, etc.), volatile and non-volatile memory devices (e.g., EEPROMs, ROMs, PROMs, RAMs, DRAMs, SRAMs, Flash Memory, firmware, programmable logic, etc.), etc. The code implementing the described operations may further be implemented in hardware logic (e.g., an integrated circuit chip, Programmable Gate Array (PGA), Application Specific Integrated Circuit (ASIC), etc.).

The described embodiments were described with respect to a tape drive **2** having heads **6***a*, **6***b*, implemented on an integrated head unit. In an alternative embodiment, the heads **6***a*, **6***b* may be on separately movable and controllable units. In alternative embodiments, the described embodiments may be used to adjust read and write heads for storage media other than tape, such as magnetic disk, optical storage, etc.

The components shown in FIG. **1** shown as separate components may be implemented in a single circuit device or functions of one illustrated component may be implemented in separate circuit devices. Moreover, operations described with respect to certain components, such as generating the interpolation time instants and correlating the data, may be performed by other components in the servo channel.

The described operations may be implemented as a method, apparatus or computer program product using standard programming and/or engineering techniques to produce software, firmware, hardware, or any combination thereof. Accordingly, aspects of the embodiments may take the form of an entirely hardware embodiment, an entirely software embodiment (including firmware, resident software, microcode, etc.) or an embodiment combining software and hardware aspects that may all generally be referred to herein as a "circuit," "module" or "system." Furthermore, aspects of the embodiments may take the form of a computer program product embodied in one or more computer readable medium(s) having computer readable program code embodied thereon.

Any combination of one or more computer readable medium(s) may be utilized. The computer readable medium may be a computer readable signal medium or a computer readable storage medium. A computer readable storage medium may be, for example, but not limited to, an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system, apparatus, or device, or any suitable combination of the foregoing. More specific examples (a non-exhaustive list) of the computer readable storage medium would include the following: an electrical connection having one or more wires, a portable computer diskette, a hard disk, an Application Specific Integrated Circuit (ASIC), FPGA (field programmable gate array), custom processors, a random access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM or Flash memory), an optical fiber, a portable compact disc read-only memory (CD-ROM), an optical storage device, a magnetic storage device, or any suitable combination of the foregoing. In the context of this document, a computer readable storage medium may be any tangible medium that can contain or store a program for use by or in connection with an instruction execution system, apparatus, or device.

A computer readable signal medium may include a propagated data signal with computer readable program code embodied therein, for example, in baseband or as part of a carrier wave. Such a propagated signal may take any of a variety of forms, including, but not limited to, electro-magnetic, optical, or any suitable combination thereof. A computer readable signal medium may be any computer readable medium that is not a computer readable storage medium and that can communicate, propagate, or transport a program for use by or in connection with an instruction execution system, apparatus, or device.

Program code embodied on a computer readable medium may be transmitted using any appropriate medium, including but not limited to wireless, wireline, optical fiber cable, RF, etc., or any suitable combination of the foregoing.

Computer program code for carrying out operations for aspects of the present invention may be written in any combination of one or more programming languages, including an object oriented programming language such as Java, Smalltalk, C++ or the like and conventional procedural programming languages, such as the "C" programming language or similar programming languages. The program code may execute entirely on the user's computer, partly on the user's computer, as a stand-alone software package, partly on the user's computer and partly on a remote computer or entirely on the remote computer or server. In the latter scenario, the remote computer may be connected to the user's computer through any type of network, including a local area network (LAN) or a wide area network (WAN), or the connection may be made to an external computer (for example, through the Internet using an Internet Service Provider).

Aspects of the present invention are described above with reference to flowchart illustrations and/or block diagrams of methods, apparatus (systems) and computer program products according to embodiments of the invention. It will be understood that each block of the flowchart illustrations and/or block diagrams, and combinations of blocks in the flowchart illustrations and/or block diagrams, can be implemented by computer program instructions. These computer program instructions may be provided to a processor of a general purpose computer, special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions, which execute via the processor of the computer or other programmable data processing apparatus, create means for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks.

These computer program instructions may also be stored in a computer readable medium that can direct a computer, other programmable data processing apparatus, or other devices to function in a particular manner, such that the instructions stored in the computer readable medium produce an article of manufacture including instructions which implement the function/act specified in the flowchart and/or block diagram block or blocks.

The computer program instructions may also be loaded onto a computer, other programmable data processing apparatus, or other devices to cause a series of operational steps to be performed on the computer, other programmable apparatus or other devices to produce a computer implemented process such that the instructions which execute on the computer or other programmable apparatus provide processes for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks.

The terms "an embodiment", "embodiment", "embodiments", "the embodiment", "the embodiments", "one or more embodiments", "some embodiments", and "one embodiment" mean "one or more (but not all) embodiments of the present invention(s)" unless expressly specified otherwise.

The terms "including", "comprising", "having" and variations thereof mean "including but not limited to", unless expressly specified otherwise.

The enumerated listing of items does not imply that any or all of the items are mutually exclusive, unless expressly specified otherwise.

The terms "a", "an" and "the" mean "one or more", unless expressly specified otherwise.

Devices that are in communication with each other need not be in continuous communication with each other, unless expressly specified otherwise. In addition, devices that are in communication with each other may communicate directly or indirectly through one or more intermediaries.

A description of an embodiment with several components in communication with each other does not imply that all such components are required. On the contrary a variety of optional components are described to illustrate the wide variety of possible embodiments of the present invention.

Further, although process steps, method steps, algorithms or the like may be described in a sequential order, such processes, methods and algorithms may be configured to work in alternate orders. In other words, any sequence or order of steps that may be described does not necessarily indicate a requirement that the steps be performed in that order. The steps of processes described herein may be performed in any order practical. Further, some steps may be performed simultaneously.

When a single device or article is described herein, it will be readily apparent that more than one device/article (whether or not they cooperate) may be used in place of a single device/article. Similarly, where more than one device or article is described herein (whether or not they cooperate), it will be readily apparent that a single device/article may be used in place of the more than one device or article or a different number of devices/articles may be used instead of the shown number of devices or programs. The functionality and/or the features of a device may be alternatively embodied by one or more other devices which are not explicitly described as having such functionality/features. Thus, other embodiments of the present invention need not include the device itself.

The illustrated operations of the figures show certain events occurring in a certain order. In alternative embodiments, certain operations may be performed in a different order, modified or removed. Moreover, steps may be added to the above described logic and still conform to the described embodiments. Further, operations described herein may occur sequentially or certain operations may be processed in parallel. Yet further, operations may be performed by a single processing unit or by distributed processing units.

The foregoing description of various embodiments of the invention has been presented for the purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form disclosed. Many modifications and variations are possible in light of the above teaching. It is intended that the scope of the invention be limited not by this detailed description, but rather by the claims appended hereto. The above specification, examples and data provide a complete description of the manufacture and use of the composition of the invention. Since many embodiments of the invention can be made without departing from the spirit and scope of the invention, the invention resides in the claims herein after appended.

What is claimed is:

1. A computer program product for handling errors when reading data on a tape media having a plurality of tracks, the computer program product comprising a computer readable storage medium having computer readable program code embodied therein that executes to perform operations, the operations comprising:

determining a first read error rate based on first read errors;

determining a second read error rate based on second read errors;

performing a first adjustment of the tension of the tape media based on the first read error rate; and

performing a second adjustment of the tension of the tape media based on the second read error rate.

2. The computer program product of claim **1**, wherein adjusting the tension comprises either increasing or decreasing the tension.

3. The computer program product of claim **1**, wherein the second adjustment of the tension of the tape media is performed in response to determining that the second read error rate is greater than the first read error rate.

4. The computer program product of claim **3**, wherein the first adjustment of the tension is in a first direction and wherein the second adjustment of the tension is in a second direction opposite the first direction.

5. The computer program product of claim **4**, wherein the first adjustment of the tension is by a first percentage and wherein the second adjustment of the tension in the second direction is by a second percentage greater than the first percentage.

6. The computer program product of claim **1**, wherein the operations further comprise:

determining whether the tape medium has expanded or contracted, wherein the performing the first adjustment and the second adjustment comprises increasing the tension in response to determining that the tape medium has expanded and decreasing the tension in response to determining that the tape medium has contracted.

7. A tape drive assembly for coupling to a tape media having a plurality of tracks, comprising:

a controller to perform operations, the operations comprising:

determining a first read error rate based on first read errors;

determining a second read error rate based on second read errors;

performing a first adjustment of the tension of the tape media based on the first read error rate; and

performing a second adjustment of the tension of the tape media based on the second read error rate.

8. The tape drive assembly of claim **7**, wherein adjusting the tension comprises either increasing or decreasing the tension.

9. The tape drive assembly of claim **7**, wherein the second adjustment of the tension of the tape media is performed in response to determining that the second read error rate is greater than the first read error rate.

10. The tape drive assembly of claim **9**, wherein the first adjustment of the tension is in a first direction and wherein the second adjustment of the tension is in a second direction opposite the first direction.

11. The tape drive assembly of claim **10**, wherein the first adjustment of the tension is by a first percentage and wherein the second adjustment of the tension in the second direction is by a second percentage greater than the first percentage.

12. The tape drive assembly of claim **7**, wherein the operations further comprise:

determining whether the tape medium has expanded or contracted, wherein the performing the first adjustment and the second adjustment comprises increasing the tension in response to determining that the tape medium has expanded and decreasing the tension in response to determining that the tape medium has contracted.

13. A method for handling errors when reading data on a tape media having a plurality of tracks, comprising:

determining a first read error rate based on first read errors;

determining a second read error rate based on second read errors;

performing a first adjustment of the tension of the tape media based on the first read error rate; and

performing a second adjustment of the tension of the tape media based on the second read error rate.

14. The tape drive assembly of claim **13**, wherein adjusting the tension comprises either increasing or decreasing the tension.

15. The tape drive assembly of claim **13**, wherein the second adjustment of the tension of the tape media is performed in response to determining that the second error rate is greater than the first error rate.

16. The tape drive assembly of claim **15**, wherein the first adjustment of the tension is in a first direction and wherein the second adjustment of the tension is in a second direction opposite the first direction.

17. The tape drive assembly of claim **16**, wherein the first adjustment of the tension is by a first percentage and wherein the second adjustment of the tension in the second direction is by a second percentage greater than the first percentage.

18. The tape drive assembly of claim **13**, wherein the operations further comprise:

determining whether the tape medium has expanded or contracted, wherein the performing the first adjustment and the second adjustment comprises increasing the tension in response to determining that the tape medium has expanded and decreasing the tension in response to determining that the tape medium has contracted.

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